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ENGINEER**

THE ENGINEERING AND ACQUISITION OF SYSTEMS OF SYSTEMS

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OUTLINE

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- **What is a System?**
- **How are Systems Acquired and Engineered?**
- **What is a System of Systems?**
- **Extending Acquisition and Engineering of Systems to Systems of Systems**
- **Supportability Implications**



WHAT IS A SYSTEM?

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- “...an assemblage of *interrelated* components that *interact* with one another in an *organized* fashion towards a *common* objective...”
 - “...a collection of parts which *interact* with each other to function as a *whole*...”
 - “...the value added by a system must come from the *relationship* among the parts, not from the parts per se...”
 - “...a collection of different things *related* in a way to produce a *result* greater than what its parts separately could produce...”
- “...a collection of components *organized* to accomplish a *specific* function or set of functions



WHAT IS A SYSTEM?

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Definition Themes

- **There Exists a Relationship, Consciously Established or Created, Among the Components of the System**
- **There Exists a Common Objective or Purpose for Each of the Components of the System, Above and Beyond any Individual Objective or Purpose for Each Component**



HOW ARE SYSTEMS ACQUIRED AND ENGINEERED?

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- **Requirements**
 - **Explicitly Stated, in Performance, Human, and Economic Terms**
 - **(Less than) Explicit Statement in Interoperability Terms**
 - **Typically do not Express the Relationships (Purposes) of the Components of the System; This Left to the Acquisition Manager (PM)**
- **Management**
 - **Budget Line (P.E.) Established 1 – 1 with the System**
 - **Program Manager (PM) Appointed**
 - **PM “Owns” \$ and has Authority to Control and Allocate**
 - **PM Incentivized to Succeed in Acquiring System: Establishes Common Objective**
 - **PM Incentivizes Component Managers Through Use and Control of Resources**
- **System Engineering**
 - **Directed by PM**
 - **Includes Organizations, People, Tools, Facilities, Rigorous Processes, Single Points of Accountability, and Decision Making**



WHAT IS A SYSTEM OF SYSTEMS

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Exceedingly Complex System?

- **Large # of Components**
- **Sophisticated or Ambiguous Nature of Relationships Among Components**
- **Lack of Specificity of Components**
- **Low Degree of Organization Within the System**

Geographically Dispersed System?

- **Regardless of Complexity**
- **Physically Widely Dispersed or Distributed**
- **Conveys “Image” of System of Systems**



WHAT IS A SYSTEM OF SYSTEMS?

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A System of Systems is an Assemblage of Components Which Individually may be Regarded as Systems and Which Possess Two Additional Properties:

- 1) Operational Independence of the Components: If the System of Systems is Disassembled into its Component Systems, the Component Systems Must be Able to Operate Independently. That is, the Component Systems Fulfill Customer or Operator Purposes on their Own.**
- 2) Managerial Independence of the Components: The Component Systems not Only *Can* Operate Independently, They *Do* Operate Independently. Component Systems are Separately Acquired and Integrated, and Maintain a Continuing Operating Existence Independent of the System of Systems**



Extending Acquisition and Engineering of Systems to Systems of Systems

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SYSTEM

- Configuration Known During Development
- Planned, Programmed, and Budgeted For
- Build Ashore
- DoD Organized to Acquire and Engineer
- Long Heritage in Stating Requirements
- Requirements State Purpose of System vs That of the Components of the System
- PM Appointed; Controls all Resources
- PM has Great Influence over Objectives of Components
- PM Controls System Engineering
- Common Objective Achieved Through Single Management of Resources
- Compatible Incentive and Reward Structure
- Common Taxonomy
- Budget Lines and Program Elements

SYSTEM OF SYSTEMS

- Configuration Known at or Near Time of Use
- Assembled
- Assemble in Theater or operating Area
- DoD not Organized to Acquire and Engineer
- Learning to State Requirements
- Requirements Typically State Purpose of System and That of the Components of the System
- PM may or may not Exist; Controls Some Resources
- PM May Have Only Marginal Influence over Objectives of Components
- PM has Marginal Control of System Engineering
- Common Objective Typically Achieved Through Consensus or Compromise; Typically no Single Management of Resources
- Orthogonal Incentive and Reward Structure
- Uncommon Taxonomy
- Budgets Typically for Coordination and Process Definition



Extending Acquisition and Engineering of Systems to Systems of Systems

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- **SYS ENGINEERING PRINCIPLE**

- **DIFFICULTY EXTENDING to SYSTEM OF SYSTEMS**

- | | |
|--|--------|
| • Know the Problem, Customer, and Consumer | Medium |
| • Use Effectiveness Criteria Based on Needs to Make System Decisions | High |
| • Establish and Manage Requirements | High |
| • Identify and Assess Alternatives to Converge on a Solution | Medium |
| • Verify and Validate Requirements and Solution Performance | High |
| • Maintain the Integrity of the System | High |
| • Use an Articulated and Documented Process | High |
| • Manage Against a Plan | High |



SUPPORTABILITY IMPLICATIONS

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- **LOGISTICS**
 - **Must be able to support changing interfaces among system components**
 - **Common approach to logistics chains for system components**
- **RELIABILITY**
 - **How to measure?**
 - **Methodology to deal with varying interactions for different configurations**
- **TEST AND EVALUATION**
 - **What is being tested?**
 - **Partitioned T&E thresholds may require rigor beyond what current acquisition community can provide**



SUPPORTABILITY IMPLICATIONS

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- **MODELLING AND SIMULATION**
 - **Must Model not only Component System,s, but Interactions**
 - **How to Validate Models?**

- **SYSTEM SAFETY**
 - **Safety aspects of interactions?**
 - **How to measure?**
 - **Is Component Level Hazard Analysis Good Enough?**



SUPPORTABILITY IMPLICATIONS

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An Over-riding Imperative:

A Common Language Across Communities



COMMON OBJECTIVE WITHOUT COMMON LANGUAGE OR LEXICON

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The Lord said, “... Come, let us go down, and there make such a babble of their language that they will not understand one another’s speech.” Thus the Lord dispersed them from there all over the earth, so that they had to stop building the city.

- Genesis 11:1-9